Advice & Counsel

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A Visit From Old Man "Whiskers"

Dear Advice & Counsel,

We are a jobshop specializing in zinc plating. Recently, a somewhat strange issue has arisen with one of our customers. This client believes that there are "whiskers" growing on our zinc plating. What is he talking about? I have sent you a sample of what our client suspects to be zinc whiskers.

Signed,
Zachary from Zinco-mania

Dear Zachary,

Whiskers on electroplated components are definitely no joke, and it appears that whiskers on zinc electroplate is a hot topic at this time (much as tin whiskers were a hot topic in the '70s and '80s). It seems that some clean rooms, in the electronics industry have been constructed with flooring panels and superstructure that was electrogalvanized (term for zinc plating that is typically thicker than 0.0005 in.). Over a few years, it was discovered that the zinc plating on the floor panels grew whiskers that were typically 2 microns in diameter and several millimeters long. When disturbed, the whiskers were dispersed into the air and the clean room was no longer "clean." The airborne whiskers could contaminate sensitive electrical devices and cause short circuits.

Over the past 50 years, there have been numerous articles written on the subject of whisker growth. My friend, Dick Baker, MSF, (R. G. Baker, Consultants, Inc.) is an expert on the subject. Here is what I have gleaned and distilled from Dick, NASA and numerous articles on the subject:

Zinc Whiskers

Zinc whiskers have always been around, but are only now becoming a "hot topic" due to the development of electronics that operate at very low voltages. At high voltages, the whiskers are vaporized, but at low voltages they cause shorts or voltage fluctuations.

Tin, zinc, cadmium, indium, and antimony are metals known to grow whiskers under special conditions. Explanations of the mechanism for such growth vary, but in general the following conditions make whisker growth more likely:

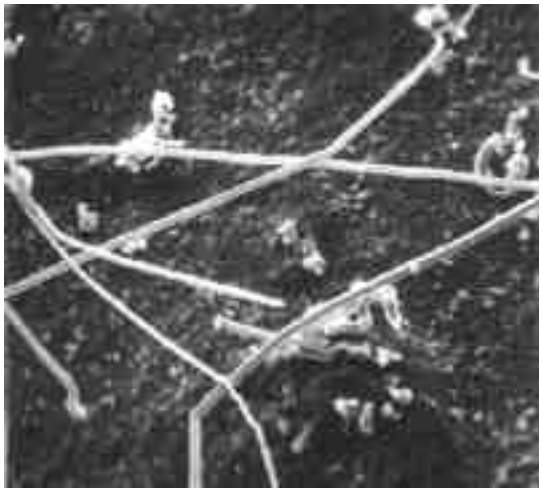
1. A deposit containing a high amount of residual stress is more likely to produce whiskers than a semi-bright or dull deposit. In general, plating solutions that contain higher concentrations of organics, organic by-products and heavy metal contamination will produce a more stressed deposit, as organics tend to incorporate carbon into the zinc deposit. For zinc plating, cyanide chemistries produce zinc deposits with the least amount of carbon content.
2. Application of compressive external stresses to the plated component.
3. A large difference between the coefficient of thermal expansion between the plated deposit and the substrate.

Whisker growth may be initiated in a matter of days or years. Growth rates of 0.03-0.09 mm/yr have been reported for tin deposits. Zinc whiskers can grow at rates up to 250 microns (0.01 in.) per year and have been reported as long as 1 cm (0.4"). The zinc whiskers typically form a basket-weave pattern (see photo)

The literature does not agree on conditions that enhance or inhibit whisker growth. Temperatures ranging from room to 122ºF (50ºC) have been reported as optimum (for tin), while it is agreed that temperatures exceeding 150ºC inhibit growth (probably due to stress relief). Thermal cycling is reported to accelerate growth or have no effect, depending on which article you read. Humidity is reported as accelerating growth or having no effect. Electrolytic fields can cause whiskers to grow in altered directions.

Researchers tend to agree that one way to avoid/inhibit the formation of whiskers is to plate an alloy instead of the pure metal. In the case of tin, reflowing eliminates the problem, but no such relief is available for zinc. The whiskers do not grow on all zinc plated surfaces (why this is the case is not fully understood at this time).

Nodules produced by welding.



Typical zinc whiskers. (Photo courtesy of www.accessfloors.com.au/zincwhiskers.htm.)

Zinc whiskers appear to be limited to electroplated deposits. No reports of whisker growth on hot dip zinc have been made to date.

As for the parts you sent me, upon visual examination, the protrusions that your client thinks might be whiskers are actually nodules that were produced by the resistance welding process, which tended to splatter metal and produce protrusions. The size, location and geometry of these nodules indicate this is a welding condition, not zinc whiskers. For reference, see the photo of typical zinc whiskers on the previous page.

You might want to look over some of the references/websites below as well.

My thanks to Dick Baker for providing some of the articles referenced. ***P&SF***

Bibliography

R. G. Baker, "The Real World of Corrosion, Spontaneous Metallic Whisker Growth," *P&SF*, **74**, No. 10, 10 (1987)

R. G. Baker, "The Real World of Corrosion, Conclusion: Whisker Growth", *P&SF*, **74**, No. 11, 12 (1987)

S. M. Arnold, "The Growth and Properties of Metal Whiskers," *Tech Proc. 43rd Annual Convention of AES* (1956)

J. R. Downs, "The Phenomenon of Zinc Whisker Growth and the Rotary Switch," *Metal Finishing*, August, 1994, p. 23

D. Loman, "How Do Zinc Whiskers Affect Today's Data Centers?" *Power Quality Assurance*, January, 2001, p. 32

www.nepp.nasa.gov/whisker/background/

www.wes.net/crs-zinc_whisker_detail.htm

www.chipcenter.com/eexpert/lgoldberg2/wtrumble002.html

www.finishing.com/0000-0199/020.html

www.accessfloors.com.au/zincwhiskers.htm